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A Survey on Physical Delivery Versus Cash Settlement in Futures Contracts

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1. Introduction

Traditionally, commodity futures contracts are settled by physical delivery at expiration. If a trader holds a short position (i.e., is a seller of futures) on the contract expiration date, he is obliged to deliver the underlying commodity at one or more pre-specified locations. Conversely, a trader with a long position (i.e., a buyer of futures) at contract expiration is obliged to receive delivery and pay at the specified price. The delivery process necessarily incurs transaction costs, which include transportation, storage, and insurance costs. In addition, the list of delivery locations and deliverable grades has important implications for the contract performance. There are two countervailing factors. A broader list reduces the possibility of market manipulation whereas a narrower list enhances hedging effectiveness. In addition, as business conditions change, the list needs to be constantly evaluated and revised.

An alternative settlement method relies on a cash index. Instead of physical delivery, cash transfer calculated from the difference between the cash index at maturity and the futures price when the position is entered takes place. For a cash-settled futures contract to perform well, the underlying cash index must fairly and accurately reflect the market conditions. While originally cash settlement is adopted for stock index futures, it has since been considered for several commodity futures markets. The construction of a good cash index remains the critical roadblock. In the United States, there are to date two cases in which the settlement method switches from physical delivery to cash settlement. The feeder cattle futures contract traded on the Chicago Mercantile Exchange (CME) changed the settlement method in September 1986 from physical delivery to cash settlement. Also, on the CME lean hog futures contracts replaced live hog futures contracts in February 1997. The former are cash settled while the latter rely upon physical delivery. In contrast, ten individual share futures (ISF) contracts traded at the Sydney Futures Exchange (SFE) switched from cash settlement to physical delivery in March 2000. In all three cases, the exchanges publicly claimed that the change would be beneficial.

Throughout the contract life, the futures price is determined by the value of the contract at maturity. Consequently, contract settlement specification has direct effects on the futures price behavior. In particular, a quality option is present under physical delivery and should be accounted for in futures pricing consideration. Due to interactions between spot and futures markets, the spot price and the basis (i.e., the difference between spot and futures prices) may behave differently when the settlement method changes. Market performance and manipulation concerns are frequently quoted as underlying rationales for changes in settlement specifications. In the case of commodities, CME proposed price convergence, basis stability, and improved hedging effectiveness to support a switch from physical delivery to cash settlement. In financial futures markets, SFE cited excessive speculation and market manipulation as the main reasons for settlement method change. Empirical investigations support the cases for feeder cattle and ISF contracts.

The remainder of this paper is organized as follows. In section 2, we briefly discuss the implicit delivery options under physical delivery. Section 3 considers the main argument against physical delivery specification, namely, market manipulation (mainly corners and squeezes). Section 4 evaluates the hedging effectiveness of a futures contract when the number of deliverable grades increases. In addition, if a cash index is established from the prices of deliverable grades under physical delivery specification, the hedging effectiveness of the cash-settled futures contract is weighed against that of the physical-delivery settled futures contract. Difficulties in choosing a cash index are discussed in section 5. Empirical results for the feeder cattle futures contract, live/lean hog futures contract, and individual share futures contracts are summarized in sections 6, 7, and 8, respectively. Conclusions are provided in section 9.

2. Implicit delivery options

Futures contracts with physical delivery are typically written with the seller given the flexibility to choose the grade of the underlying commodity to deliver (quality option), the location to deliver (location option), and the time (within a specified period) to deliver (timing option). Such flexibility is granted to the short-interest holder at the expense of the long-interest holder, and functions effectively as embedded options. These options will reduce the futures price from what it would be without such options. An excellent survey on this topic is provided by Chance and Helmer (1993).

Boyle (1989) provided a general algorithm to evaluate the quality option. He considered a setup in which asset prices are assumed to follow geometric Brownian motions so that the returns of the deliverable underlying assets follow a multivariate normal distribution. Assuming the futures price is equal to the forward price, Boyle (1989) showed that the futures price can be obtained as the call option on the minimum (or maximum) of the underlying assets. Under the assumption that the returns of each pair of assets have the same correlation coefficient he derived an algorithm to evaluate the futures value, which is feasible for even a large number of multiple assets such as 50.

It can be seen that if the underlying assets are perfectly correlated the quality option has no value. A larger discount is expected when the correlations are lower. Boyle's (1989) numerical computations showed that when the correlation coefficient is 0.95, the discount of the futures price relative the one-asset benchmark is about 5 percent when there are 4 deliverable assets (with time to maturity of 0.75 years, rate of interest 10 percent, volatility of 25 percent per annum and asset price of 40). The discount increases to about 10 percent when there are 30 deliverable assets. The assumption of equicorrelation was later relaxed in a paper by Boyle and Tse (1990).

Boyle (1989) provided further analysis of the impact of the timing option. He showed that if there is only one deliverable asset, the timing option has no value. Indeed, the short should optimally deliver the asset at the first permitted opportunity. When the contract permits more than one deliverable asset, there is interaction between the timing option and quality option. Boyle's (1989) numerical analysis, however, shows that the impact of the timing option is small.

The above results assume that there is no cash flow (coupon or dividend) generated by the deliverable assets. Thus, the method does not apply to Treasury bond futures contracts. Furthermore, the assumption of geometric Brownian motion will not apply to bond futures. For the Treasury bond futures traded on the Chicago Board of Trade (CBOT), the timing option is further complicated by the rules on the accrued interest, wild card and end-of-month options. Gay and Manaster (1986), Hegde (1988), and Hemler (1990) examined the various embedded options in the Treasury bond futures contract. For futures contracts on commodities with different grades, premiums and discounts may be specified with respect to a "standard" variety. Kilcollin (1982) and

Garbade and Silber (1983b) discussed the issues of the determination of the premiums and discounts. Garbade and Silber (1983b) argued that the appropriate determination of premiums and discounts helps to allocate unhedgeable risks among market participants. However, they pointed out that the contract premium or discount need not be set according to the normal commercial counterpart.

3. Maintenance costs, delivery costs, and contract manipulation

Under physical delivery the contract's roster of deliverable grades and delivery locations must be revised periodically in response to changes in market conditions. If disparities are allowed to arise between contract specifications and common business practice, the futures delivery costs may increase and this may create opportunities for market manipulation. On the other hand, cash-settled contracts may also entail many of the maintenance costs found in physical-delivery contracts. Specifically, the index on which a cash-settled futures contract is based must be modified by the exchange officials from time to time in response to changes in market structure and practice, if the contract is to remain useful to market participants and robust to attempted manipulation.

Economic frictions such as transportation and transaction costs may isolate markets and consumers. They distort the delivery costs and consumption, which in turn cause artificial price changes. Pirrong (1993) demonstrated that increasing marginal cost of delivery is a necessary condition for the holder of a long futures position to be able to profit by manipulating the market, and that economic costs such as transportation costs may induce an increasing marginal cost of delivery. Manipulation causes price distortion, reduces hedging effectiveness and is a source of welfare loss. Pirrong (1993) also showed that transportation costs can make manipulation by a large short trader profitable.

Manipulation occurs in the futures market when some players use the delivery features of a contract to manipulate prices in their favour. Market cornering is a common type of manipulation. To corner a market, a trader holds a long futures position and a position in the underlying commodity that are very large. If he demands delivery on his long futures contract and refuses to sell his commodity in the spot market, the shorts will have difficulty acquiring sufficient commodity for delivery. Thus, the long manipulator squeezes the shorts by charging high price to relieve the shorts of their obligation to deliver. Cooper and Donaldson (1998) proposed a game-theoretic model for analyzing corner-and-squeeze manipulation. To prevent manipulation, they recommended policies designed to increase deliverable supply, such as replacing physical delivery with cash settlement, and decrease individual's position size.

Manipulation strategies under cash settlement were examined by Kumar and Seppi (1992). A case study of cash settlement, involving the December 1995 municipal bond futures, was provided by Cornell (1997). Barnhart, Kahl, and Barnhart (1996), and Pirrong (1998) discussed possible manipulation of the July 1989 soybean futures contract. For a general discussion of market manipulation in physical delivery futures contracts, see Jones (1983) and Paul (1985). Theoretical investigations of corners and squeezes include Jarrow (1992), Pirrong (1993, 1995, 1997a), and Mollgaard (1997).

4. Market Performance

As with manipulation, hedging performance of futures contracts is a pivotal concern for exchanges and regulators. Fort and Quirk (1988) and Lien (1987) suggested that for a physical-delivery futures contract with a broad-based delivery basket the so-called inventory effect may arise between the cash and futures prices, which helps explain the prevalence of backwardation, namely, the forward price of a commodity is less than its spot price. The inventory effect arises because when the inventories of a good are large, the prices of different grades of the commodity tend to be determined more by the commodity's common characteristics than by their distinctive characteristics. That is, the different grades of commodity are better substitutes for one another when the stocks are large than when they are small. This implies the futures prices tend to be more highly correlated with the spot prices at low prices than at high prices. This correlation pattern renders the effectiveness of the futures contract for the short hedgers but not for the long hedgers, and explains the preponderance of short over long hedging. Lien (1986) and Lien and Balakrishnan (2003) provided theoretical analyses for the existence of the inventory effect.

Karama and Siegel (1987) analyzed the hedging effectiveness of a futures contract with multiple delivery specifications using the CBOT wheat futures as an empirical example. Lien (1988, 1991) employed their framework to examine the choice by the short and long hedgers between contracts with narrow-based and broad-based delivery baskets. He argued that narrow-based contracts should be better hedging instruments for the market when the short hedgers express the same preference as the long hedgers, who always prefer narrow-based contracts. On the other hand, if the short-hedgers prefer broad-based contracts, there will be conflicting interests between the short and the long hedgers. Market level criteria must then be employed to the choice of the specification. Lien (1989a) considered the scenario where both narrow-based and broad-based futures contracts coexist, and showed that sometimes the two contracts may complement each other. Thus, the CBOT wheat futures contract actually helps promote the Kansas City Board of Trade (KBOT) wheat futures markets.

All the above analyses rely upon the mean-variance approach. For the broad-based futures contract, the approach cannot be justified by conventional arguments. Lien (1992) evaluated the effect of this incorrect assumption on the optimal hedging decision. Lien and Rearden (1996, 1998) developed new statistical results for ordered log-normal distributions to further characterize the hedging effectiveness of broad-based futures contracts.

Garbade and Silber (1983b) were the first to analyze the hedging performance of a cash-settled futures contract. Lien (1989b) compared the hedging effectiveness of a cash-settled contract with a broad-based physical delivery contract that allows for the same multiple delivery grades. He argued that cash-settlement contract is preferred whenever it generates smaller variance for the futures price. Risk aversion and storage costs have no effect. If, however, the cash-settlement method leads to a larger variance, there may be instances for which physical delivery is preferred. Within this framework, Lien (1989c) determined the cash-settlement index that is optimal (in the sense that it maximizes a hedger's welfare and the contract's trading volume). Lien (1990) incorporated competition among exchanges into the model and derived the cash-settlement index that is optimal for any one exchange for the purpose of preventing the listing of competitive futures contracts by other exchanges.

5. Constructing a Cash-Settlement Index

When the assets or commodities that underlie a cash-settled futures contract are not publicly traded, the exchange on which the contract is listed must rely upon price-reporting agents to generate the expiration value of the cash-settlement index. Examples include the Eurodollar futures and municipal bond futures. Sutcliffe (1997) noted a potential structural flaw in this expiration scheme in the context of the FTSE-100 index futures. Specifically, a price-reporting agent may be motivated to provide a biased report. Suppose for example the agent holds a long position; he might report a price quote higher than the true price. Similarly, an agent with a short position might provide a downward-biased price quote. Cornell (1997) provided empirical evidence of manipulation in the municipal bond futures markets near contract expiration. On the other hand, Frino and Lodh (2001) suggested that the truncation procedure adopted in the Australian bond futures contract removes the option expiration effects.

To reduce the incidence of reporting biases exchanges often apply filters (e.g., sample trimming) to the quotes provided by price-reporting agents. For example, for the Eurodollar futures at the Chicago Mercantile Exchange (CME) before the 1990s, twelve price quotes were collected, but the highest two and the lowest two were discarded before the exchange computed the contract expiration value. Similarly, for the municipal bond futures, six price quotes are submitted, and the arithmetic average of the middle four quotes is used in computing the cash-settlement index. Also, the government bond futures contract traded on the SFE adopts a truncation procedure similar to the Eurodollar contract as it applies to both bid and ask quotes.

Lien (1989d) adopted a game-theoretic approach to evaluate the effect of sample trimming in reducing the impact of biased price reports. Assuming a median procedure is adopted for the cash index (such as the now demised GNMA futures contract), the explicit expression for the bias is derived. It is positively related to the benefit of misreporting and negatively related to the sample size and the extent of sample truncation. Cita and Lien (1992a) discussed cash index construction, particularly the tradeoff between bias reduction and price accuracy, and compared several possible index construction methods. The main issue here is as follows. Suppose we have a collection of random samples. How do we estimate the mean of the underlying population distribution when some data points may be unreliable? Each reported number represents a quote eligible for the construction of the cash index. The number may be an accurate actual observation, or it may be an inaccurate observation based on an unintentional misreport. Also, it could be an intentional misreport (i.e., market manipulation) distorted to serve self-interest.

When there are no intentional or unintentional misreports, each sample observation contains information value. A general perception is that, data trimming will reduce estimation efficiency. This is clearly the case when the sample data are drawn from a normal distribution. The loss of efficiency is dependent on the trimming percentage (i.e., the reduced sample size). For a double exponential distribution, the maximum likelihood estimator is the sample median. Therefore, symmetric trimming on the extreme points has no effect on estimation efficiency. On the other hand, the maximum likelihood estimator for a uniform distribution is the average of the sample maximum and the sample minimum. Symmetric trimming on the extreme points leads to efficiency loss. Thus, the efficiency loss depends upon the shape of the density function.

On the other hand, intentional misreport is similar to the outlier problem in statistical inference. If a misreport lies in the middle of the numbers reported, it is very difficult, if possible at all, to detect. However, the impact of this misreport is likely to be minimal and tolerable. The extremely large or small misreports are of concern, as they produce greater impact on the index. Symmetric trimming on the extremes therefore remove damaging intentional misreports. Unfortunately, when the extremes are actual accurate reports, the procedure removes reliable and possibly influential sample observations instead. A tradeoff between bias reduction and efficiency loss occurs.

For a futures contract in which the expiration value of the underlying cash-settlement index is the arithmetic mean of the prices reported, Cita and Lien (1997a) proposed an adaptive truncation procedure in which the sample truncation percentage is data driven. Specifically, bootstrap methods are applied to determine the optimal sample proportion to trim. Using the municipal bond futures as an example, they showed that both adaptive trimming and adaptive winsorization estimators perform very well under various scenarios of distributions and contamination. Berkowitz (1998) suggested applying bootstrap methods to the Huber estimator instead of the trimming estimators. Simulation results indicate that the new estimator performs better than the Cita-Lien estimator under the normality assumption and equally well under the student *t* distribution. Shah (1998) found that the Cita-Lien estimator works well for India's call money market.

While data driven cash index may be statistically superior, futures market participants may not feel at ease. Cita and Lien (1997b) reconsidered the fixed weight estimators. Instead of trimming (i.e., assigning a weight of zero), L-moment estimators and compromise estimators are applied to determine the optimal weighting schemes for the sample of six numbers collected in the municipal bond futures contract. Simulation results demonstrate better performance for the new estimators.

Finally, in all the above papers, the cash-settlement index is calculated as a weighted arithmetic average of market prices. Lien and Luo (1993) adopted the Kyle (1984, 1985) framework to compare a cash-settled contract based upon a geometric average to a contract based upon an arithmetic average. They argued that the former may perform better than the latter and that, consequently, the switch from a geometric average to an arithmetic average by the KBOT for its Value Line index futures contract was without merit.

6. Empirical results: Feeder cattle futures contracts

The first generation of empirical studies on physical delivery versus cash-settlement for the feeder cattle contracts used simulation to compare the two settlement methods. Hauser, Chaherli and Thompson (1992) and Chaherli and Hauser (1993) considered the hypothetical effects of converting soybean futures from physical delivery to cash settlement. Kahl, Hudson and Ward (1989) examined the issue of live cattle futures. Kimle and Hayenga (1994) considered live hog futures. Paul (1987) and Leuthold (1992) discussed the effects of cash settlement on livestock futures contracts. Ditsch and Leuthold (1996) employed simulation to evaluate live/lean hog futures.

Harris (1990) discussed the usefulness of some recent cash-settled index derivative products.

In all the above studies, there is only a physical-delivery futures contract the price of which is observable. To evaluate the effect of a cash-settled futures contract, a hypothetic futures price series must be constructed. Given a cash index, one may adopt the price convergence assumption and set the futures price for the cash-settled contract equal to the cash index during the maturity period (e.g., the delivery month or two weeks before the expiration date). From the constructed futures price we can compare the volatility of the futures price and the basis stability during the maturity period across the two contracts: the actual prevailing physical-delivery contract and the hypothetical non-existing cash-settled contract. Moreover, we can evaluate and compare the performance of a hedge strategy where the futures position is held until the maturity period under the two different settlement specifications. While the above studies generally find the switch from physical delivery to cash settlement in commodity futures lead to improvement in market performance, the results are not reliable as the price convergence assumption is not likely to be valid.

To investigate the issue with actual data, one may consider the feeder cattle futures contract. This contract switched from physical delivery to cash settlement in September 1986. Therefore, there are two futures price series: for the physical-delivery period and the cash-settlement period. Data from this historical experience permits one to study the impact of converting a futures contract market from physical delivery to cash settlement. Indeed, one can evaluate and compare the market performance under different settlement specifications using these two futures price series. Elam (1988), Schroeder and Mintert (1988), Kenyon, Bainbridge and Ernst (1991), Rowsell and Purcell (1990), Rich and Leuthold (1993), and Schmitz (1997) all investigated this issue, employing various data samples and diverse statistical methods. A consensus finding is that both the futures price and the basis become more stable after cash settlement is adopted. However, hedging effectiveness may increase or decrease depending upon the location of the hedger, which determines the specific spot price series to use in the statistical analysis.

Chan and Lien (2001) employed the Geweke feedback measures to evaluate information flows before and after the changes in the settlement method. They found that the price discovery function of the futures market (i.e., the information flows from the futures market to the spot market so that the former leads the latter in price changes) performs better under the cash-settlement system. In addition, there are more contemporaneous information flows between the two markets, signaling better market integration.

Common to all the above studies is the assumption that price volatility is constant across the intervals before and after the conversion from physical delivery to cash settlement. Modern statistical tests tend to invalidate this assumption for most economic and financial time series. Lien and Tse (2002) adopted a generalized autoregressive conditional heteroskedasticity (GARCH) specification to describe spot and futures price volatility, which is validated by the sample data. Although their model allows the correlation between the two prices to vary over time, empirical evidence however suggests the correlation coefficient to be constant. A dummy variable characterizing the settlement specification is incorporated in the conditional mean and variance equations to investigate the effect of the switch to cash settlement. It is found that the change in the settlement specification has no impact on the means of the spot and futures returns, and henceforth no impact on the mean of the basis as well. The volatility of the futures market, however, decreases although the volatility of the spot market is not affected by the switch to cash settlement. In addition, the basis becomes more stable.

Under the assumption of minimum-variance hedge, when the market volatility changes over time the optimal hedge ratio becomes time varying as well. Lien and Tse (2002) found that the dynamic optimal hedge ratio becomes larger on average and more stable after cash settlement is adopted. Thus, the hedging effectiveness of the feeder cattle futures contract improves accordingly.

While Lien and Tse (2002) enlisted several statistical tests to validate their GARCH specification, one may consider alternative models to estimate the time varying volatility. Chan and Lien (2002) applied the stochastic volatility models of Harvey, Ruiz and Shephard (1994). Empirical results sustain the conclusions of Lien and Tse (2002) concerning market performance. In addition, it is found that the volatility of both prices and the basis all become less persistent after cash settlement is adopted. That is, a large volatility is less likely to be followed by another large volatility. As a consequence, cash settlement reduces the volatility of volatility in both the spot and futures markets.

Suppose that data on the highest and lowest price of each day are available, we can apply range estimators to derive the market volatility. While the GARCH and stochastic volatility models treat the market volatility as a latent variable, the range approach provides estimated volatility on a daily basis; see Garman and Klass (1980) and Rogers and Satchell (1991). Chan and Lien (2003) adopted four different range estimators for the daily volatility to examine the effect of cash settlement on the feeder cattle futures market. It is found that all measures suggest that the futures market has become more stable after the switch to cash settlement. With the exception of the Garman-Klass estimates, the empirical results also suggest that the futures market experienced a decrease in the volatility of volatility. Because there is no daily range data available for the spot price (due to, among other reasons, infrequent trading on the spot market), a similar analysis cannot be applied to the spot market.

In summary, regardless of the volatility estimation method, the feeder cattle futures market becomes more stable after cash settlement replaces physical delivery. Not only the volatility of the futures price declines, but the volatility of volatility declines as well. The settlement-method change has no effect on the spot market. The basis becomes more stable although there is no change in the average level. The dynamic minimum-variance hedge ratio increases on average and experiences smaller fluctuations. The empirical evidence showed that the feeder cattle futures contract becomes a more effective hedging instrument after cash settlement is adopted.

7. Empirical results: Live/lean hog futures contracts

The last live hog futures contract traded at the CME expired in December 1996. The first cash-settled lean hog futures contract started in February 1997. The CME asserted the new contract would have lower basis variability and would attract more commercial interests. Indeed, prior to this change, Ditsch and Leuthold (1996) noticed a significant decline in trading volume at the terminal markets.

Kimle and Hayenga (1994) examined the cash-settlement issues in the live hog markets. Using simulated data, they found that cash settlement provides better convergence between the cash and futures prices. Moreover, the basis variability is significantly reduced. Similarly, Ditsch and Leuthold (1996) constructed optimal hedge ratios from simulated data. They found that the lean hog futures contract provides better hedging effectiveness than the live hog futures contract.

Lien and Tse (1999) used the actual lean hog futures price data to evaluate the effect of cash settlement on the live/lean hog markets. It is found that GARCH effects prevail in the spot return series but not in the futures return or the basis series. Incorporating a dummy variable to represent the settlement method, they found the basis and spot and futures returns all become more volatile after cash settlement is adopted. These results are drastically different from the feeder cattle case.

Adopting the Geweke measures, Chan and Lien (2001) showed that there are strong information flows between the spot and futures markets during the physical-delivery period. While overall instantaneous information flow is the dominant factor, the price discovery function of the futures market cannot be ignored. In comparison, the feedback from the spot to futures markets declines during the cash-settlement period and is statistically significant at any conventional level. There is also a reduction in the futures-to-spot feedback measure, implying that the discovery function of the futures market has dwindled. Although the instantaneous feedback increases, the total feedback actually decreases by nearly 15%. Thus, after cash settlement is adopted, the spot and futures markets react more responsively and quickly to the new information. Beyond these simultaneous reactions, there is little information flow between the two markets. Although the futures market still leads the spot market, its importance has diminished considerably. Once again, contrary to the feeder cattle case, cash settlement leads to poorer performance in the live/lean hog markets. Concerned with the noises associated with market transition, Chan and Lien (2001) deleted the first three months of data from the lean hog futures markets and re-calculated the Geweke measures. Nonetheless, they found the above results remain unchanged.

Given the contradicting conclusions between feeder cattle markets and live/lean hog markets, some possible explanations deem necessary. Both Lien and Tse (1999) and Chan and Lien (2001) suggested that the conclusions for the live/lean hog case be treated with caution. First, in their studies the sample size is rather small, a total of 152 observations for the lean hog futures contract. As the Geweke measures are applicable only in large samples, the small sample size for the hog studies casts doubts on the reliability of the empirical results and conclusions derived thereof. Secondly, along with the change from physical delivery to cash settlement, the lean hog futures contract also adopts a different weighing scheme from the live hog futures. The original live futures contract adopts live weight measure whereas the new lean hog futures contract adopts carcass weight measure. Based on the industry average, one pound of live weight equals to 0.74 pound of carcass weight. However, the exact conversion factor varies from case to case. Because the spot price continues to rely on the live weight, the new futures contract introduces additional uncertainty to the relationship between the spot and lean hog futures prices, which adversely affect the performance of the new futures market.

Finally, one must respect the effect of the contract name change. In the case of the feeder cattle contract, when the exchange replaces physical delivery with cash settlement, there is no other simultaneous critical change in the contract specification. Thus, the name of the contract is reserved and the exchange simply replaces the original physical-delivery feeder cattle futures contract by a new cash-settled feeder cattle futures. Similar approaches are adopted in Lien and Tse (1999) and Chan and Lien (2001) for the hog markets. That is, they treated the cash-settled lean hog futures contract as equivalent to a cash-settled live hog futures contract to draw conclusions regarding the effects of cash settlement. However, when launching the settlement method change in the hog futures contract, CME also highlights the change from live weight to carcass weight to be a major and critical measure. Accordingly, the "live hog" futures contract is abandoned and replaced by the "lean hog" futures contract. Market participants are therefore likely to treat the lean hog futures contract as a new contract instead of a differently settled futures contract. The comparisons between the performance of live hog and lean hog futures contracts therefore do not provide a meaningful observation to evaluate the effects of the cash-settlement method.

Using an extended sample, Chan and Lien (2004) compared implied volatility from options on live hog futures and options on lean hog futures to examine the effect of cash settlement. Specifically, for each day the implied volatility is measured by the average of the implied volatility for the two nearest-the-money puts and the two nearest-the-money calls. A regression analysis indicates that the implied volatility decreases after cash settlement replaces physical delivery. Similar results are obtained after adopting GARCH specifications to account for conditional heteroskedasticity in the implied volatility series. Thus, the lean hog futures market is more stable than the live hog futures market, a finding not supported by previous studies. Note that, while the GARCH model employed in Lien and Tse (1999) considers the "contemporaneous" volatility, the implied volatility measures "future" volatility.

8. Empirical results: Australian individual share futures contracts

While the above two commodity futures contracts switch from physical delivery to cash settlement, the ISF contracts in Australia change from cash settlement to physical delivery. ISF contracts were first introduced in 1994. Initially the contracts were settled in cash. In 1996, cash settlement was gradually replaced by physical delivery. Lien and Yang (2003c) adopted the analytical techniques of Lien and Tse (2001) to examine the effects of the change in contract specification on the ten ISF contracts. They found that, after the switch from cash settlement to physical delivery, the futures market, the spot market, and the basis all become more volatile. That is, prices and the bases are more volatile under physical-delivery specifications, consistent with theoretical predictions and the findings from the feeder cattle studies. On the other hand, in spite of increasing volatility, the hedging effectiveness of each ISF contract increases after the settlement method change. The improvement in hedging effectiveness is particularly impressive for the most recently established individual share futures contracts. Thus, the ISF futures contract is a more effective hedging instrument under physical-delivery requirement. In contrast, the feeder cattle futures contract is more effective with cash-settlement specification.

Lien and Yang (2003b) evaluated information flows between ISF futures market and the corresponding stock market. They found that, due to the small trading volume of the ISF contract, there is no statistically significant information flow from the futures market to the spot market but there exists significant information flow from the spot market to the futures market during both the cash-settlement and physical-delivery periods. These findings indicate that the spot market dominates the futures market. In addition, the magnitude and statistical significance of the information flow from the spot market to the futures market both increased after the switch from cash settlement to physical delivery in the ISF contracts. Thus, the information-leading role of the spot market is strengthened. It is also found that the physical-delivery requirement of the ISF contracts increases the instantaneous information flows between the spot and futures markets. The dependence between the spot and futures markets therefore becomes stronger after the futures contracts switch from cash settlement to physical delivery.

Using Spanish data, Corredor, Lechon, and Santamaria (2001) suggested that options settlement method affects the magnitude of option expiration-day effects. Lien and Yang (2003a) examined the impact of the ISF contract settlement method on the option's expiration-day effects. Using daily data, they found that the cash-settled ISF contracts attenuate the expiration-day effects on price volatility and trading volume. After physical delivery replaces cash settlement, stock prices tend to move up near expiration days. Otherwise, the settlement method change has little impact on the expiration effects in terms of stock volatility and trading volume.

Lien and Yang (2003d) revisited the issues with transaction data. It is found that significant expiration-day effects exist on price volatility and trading volume in the absence of individual stock futures. After cash-settled stock futures contracts are available, price volatility on expiration days decreases notably and changes from significantly higher than to significantly lower than those on non-expiration days, which is consistent with but stronger than the results based on the daily data. Trading volume remains nearly unchanged. The switch from cash settlement to physical delivery, however, increases the volatility effect. For some stocks, the volatility effect is insignificant during the cash-settlement period and becomes significant when physical delivery is required. Price reversals on expiration days are abnormally higher than those on non-expiration days. This is expected as price reversal is positively related to price volatility. In sum, while transaction data analysis leads to different results from the daily data analysis, these results are more consistent with the perception that spot and futures prices become more volatile after physical delivery replaces cash settlement in the ISF contracts.

9. Conclusions

When the underlying asset of a futures contract is heterogeneous with a high delivery cost, cash settlement appears to be a better alternative to physical delivery. The feeder cattle futures contract at the Chicago Board of Trade provides a good example. After cash settlement replaces physical delivery, both spot and futures markets become more stable. Price convergence is smoother as the basis is less volatile. Hedging effectiveness improves as well. Completely reversed conclusions apply to the case when the physical-delivery live hog futures contract is replaced by cash-settled lean hog futures contract. However, there are other major changes that occur simultaneously with the contract replacement. We suspect the impact presented in the data analysis include effects other than those from the change in settlement specification. Thus, we suggest the hog market analysis results be treated with caution.

Although we expect a well-designed cash-settlement contract to perform better than physical-delivery contract, the choice of the underlying cash index is a difficult task. Even if a good cash index is found, market liquidity is another concern. If a physical-delivery futures contract is established and successful, a proposal to replace the contract with an alternative cash-settled contract will encounter strong objection from market participants. Only when spot market conditions change and the list of deliverable grades and delivery locations deems inappropriate, cash settlement may become a viable candidate. As a result, the development of cash-settled commodity futures contract will be slow and painstaking.

Government bond futures contract is an interesting case. Herein the underlying asset is heterogeneous but the delivery cost is small. Treasury bond futures contracts traded at the Chicago Board of Trade require physical delivery. Conversion factors determine premiums and discounts. The calculation of conversion factors is cumbersome. Nonetheless, the success of the contract will likely deter any proposal of cash-settlement alternatives in the conceivable future. On the other hand, the Australian 10-year commonwealth Treasury bond futures contract traded on the Sydney Futures Exchange adopts cash settlement. Theoretical analysis indicates that cash settlement would perform better than physical delivery. Based upon hypothetical futures prices under physical delivery and the actual futures price under cash settlement, Lin and Chou (1998) provided some empirical support for the theoretical prediction of the Australian contract.

If the underlying asset of a futures contract is homogeneous, physical delivery is a better alternative unless the delivery cost is too high. Empirical evidence from the Australian individual shares futures contracts are consistent with the theoretical analysis. Both the spot and futures prices become more volatile after physical delivery replaces cash settlement in these contracts, and so does the basis. However, hedging effectiveness improves after the settlement specification changes, indicating the new contract is a better hedging instrument.

Uncited references
Garbade & Silber, 1983a

Pirrong, Kormendi, & Meguire, 1994

References

Barnhart, S. W., Kahl, K. H., and Barnhart, C. M. (1996): "An Empirical Analysis of the Alleged Manipulation Attempt and forced Liquidation of the July 1989 Soybean Futures Contract," *Journal of Futures Markets*, 16, 781-808.

Berkowitz, J. (1998): "Dealer Pooling in the Presence of Possibly Noisy Reporting," Financial and Economic Discussion Series, 1998-33, Division of Research & Statistics and Monetary Affairs, Federal Reserve Board, Washington, D.C.

Boyle, P. P. (1989): "The Quality Option and the Timing Option in Futures Contracts," *Journal of Finance*, 44, 101-113.

Boyle, P. P. and Tse, Y. K. (1990): "An Algorithm for Computing Values of Options on the Maximum and Minimum of Several Assets," *Journal of Financial and Quantitative Analysis,* 25, 215-227.

Chaherli, N. M. and Hauser, R. J. (1993): "Delivery Systems versus Cash Settlement in Corn and Soybean Futures Contracts," Mimeo.

Chan, L. and Lien, D. (2001): "Cash Settlement and Price Discovery in Futures Markets," *Quarterly Journal of Business and Economics*, 40, 65-77.

Chan, L. and Lien, D. (2002): "Measuring the Impacts of Cash Settlement: A Stochastic Volatility Approach," *International Review of Economics and Finance*, 11, 265-275.

Chan, L. and Lien, D. (2003): "Using High, Low, Open and Closing Prices to Estimate the Effects of Cash Settlement on Futures Prices," *International Review of Financial Analysis*, 12, 35-47.

Chan, L. and Lien, D. (2004): "Cash Settlement and Futures Price Volatility: Evidence from Options Data," *Advances in Quantitative Analysis of Finance and Accounting*, forthcoming.

Chance, S. and Hemler, M. L. (1993): "The Impact of Delivery Options on Futures Prices: A Survey," *Journal of Futures Markets*, 13, 127-155.

Cita, J. and Lien, D. (1992a): "Constructing Accurate Cash Settlement Indices: The Role of Index Specifications," *Journal of Futures Markets*, 12, 339-360.

Cita, J. and Lien, D. (1997a): "Estimating Cash Settlement Price: The Bootstrap and Other Estimators," *Journal of Futures Markets*, 17, 617-632.

Cita, J. and Lien, D. (1997b): "Improving the Weighting Schemes of Cash Settlement Indices," *Review of Securities and Futures Markets*, 9, 91-127.

Cooper, D. J. and Donaldson, R. G. (1998): "A Strategic Analysis of Corners and Squeezes," *Journal of Financial and Quantitative Analysis*, 33, 117-137.

Cornell, B. (1997): "Cash Settlement when the Underlying Securities Are Thinly Traded: A Case Study," *Journal of Futures Markets*, 17, 855-871.

Corredor, P., Lechon, P., and Santamaria, R. (2001): "Option-expiration Effects in Small Markets: The Spanish Stock Exchange," *Journal of Futures Markets* 21, 905-928.

Ditsch, M. and Leuthold, R. (1996): "Evaluating the Hedging Potential of the Lean Hog Futures Contract," OFOR Paper Number 96-03, Office for Options and Futures Research, University of Illinois at Urbana-Champaign, Urbana, Illinois.

Elam, E. (1988): "Estimated Hedging Risk with Cash Settlement Feeder Cattle Futures," *Western Journal of Agricultural Economics*, 13, 45–52.

Fort, R. and Quirk, J. (1988): "Normal Backwardation and the Inventory Effect," *Journal of Political Economy*, 96, 81-99.

Frino, A. and Lodh, S. (2001): "Expiration-Day Effects on Bond Futurs and Options: Evidence from the Sydney Futures Exchange," Working paper, Department of Finance, University of Sydney, Australia.

Garbade, K. and Silber, W. (1983a): "Cash Settlement of Futures Contracts: An Economic Analysis," *Journal of Futures Markets*, 3, 451-472.

Garbade, K. and Silber, W. (1983b): "Futures Contracts on Commodities with Multiple Varieties: An Analysis of Premia and Discounts," *Journal of Business*, 56, 249-272.

Garman, M. B. and Klass, M. J. (1980): "On the Estimation of Security Price Volatilities from Historical Data," *Journal of Business*, 53, 67-78.

Gay, G. D. and Manaster, S. (1986): "Implicit Delivery Options and Optimal Delivery Strategies for Financial Futures Contracts," *Journal of Financial Economics*, 16, 41-72.

Harris, L. (1990): "The Economics of Cash Index Alternatives," *Journal of Futures Markets*, 10, 179-194.

Harvey, A., Ruiz, E. and Shephard, N. (1994): "Multivariate Stochastic Variance Models," *Review of Economic Studies*, 61, 247-264.

Hauser, R., Chaherli, N. and Thompson, S. (1992): "Cash Settlement for Corn and Soybeans: A Preliminary Analysis," NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management.

Hegde, S. (1988): “An Empirical Analysis of Implicit Delivery Options in the Treasury Bond Futures Contract,” *Journal of Banking and Finance*, 12, 469-492.

Hemler, M. L. (1990): “The Quality Delivery Option in Treasury Bond Futures Contracts,” *Journal of Finance*, 45, 1565-1586.

Jarrow, R. A. (1992): “Market Manipulation, Bubbles, Corners, and Short Squeezes,” *Journal of Financial and Quantitative Analysis*, 27, 311-336.

Jones, F. J. (1983): “The Economics of Futures and Options Based on Cash Settlement,” *Journal of Futures Markets*, 3, 63-82.

Kahl, K. H., Hudson, M. A., and Ward, C. E. (1989): “Cash Settlement Issues for Live Cattle Futures Contracts,” *Journal of Futures Markets*, 9, 237-248.

Kamara, A. and Siegel , A. (1987): “Optimal Hedging in Futures Markets with Multiple Delivery Specifications,” *Journal of Finance*, 42, 1007-1021.

Kenyon, D., Bainbridge, B., and Ernst, R. (1991): “Impact of Cash Settlement on Feeder Cattle Basis,” *Western Journal of Agricultural Economics*, 16, 93–105.

Kilcollin, T. E. (1982): “Difference Systems in Financial Futures Markets,” *Journal of Finance*, 37, 1183-1197.

Kimle, K. and Hayenga, M. L. (1994): “Cash Settlement as an Alternative Settlement Mechanism for the Live Hig Futures Contract,” *Journal of Futures Markets*, 14, 347-361.

Kumar, P. and Seppi, D. J. (1992): “Futures Manipulation with Cash Settlement,” *Journal of Finance*, 47, 1485-1502.

Kyle, A. (1984): “A Theory of Futures Market Manipulation,” in: R. W. Anderson (ed.) *The Industrial Organization of Futures Markets*. Lexington: Lexington Books.

Kyle, A. (1985): “Continuous Auctions and Insider Trading,” *Econometrica*, 53, 1315 -1335.

Leuthold, R. M. (1992): “Cash Settlement versus Physical Delivery: The Case of Livestock,” *Review of Futures Markets*, 11, 175-183.

Lien, D. (1986): “Moments of Ordered Bivariate Log-Normal Distributions,” *Economics Letters*, 20, 45-47.

Lien, D. (1987): “The Inventory Effect in Commodity Futures Markets: An Empirical Study,” *Journal of Futures Markets*, 7, 637-652.

Lien, D. (1988): "Hedger Response to Multiple Grades of Delivery on Futures Markets," *Journal of Futures Markets*, 8, 687-702.

Lien, D. (1989a): "Optimal Hedging and Spreading on Wheat Futures Markets," *Journal of Futures Markets*, 9, 163-170.

Lien, D. (1989b): "Cash Settlement provisions on Futures Markets," *Journal of Futures Markets*, 9, 263-270.

Lien, D. (1989c): "Optimal Settlement Specifications on Futures Contracts," *Journal of Futures Markets*, 9, 355-358.

Lien, D. (1989d): "Sampled Data as a Basis of Cash Settlement Price," *Journal of Futures Markets*, 9, 538-588.

Lien, D. (1990): "Entry-Deterring Contract Specification on Futures Markets," *Journal of Futures Markets*, 10, 89-95.

Lien, D. (1991): "Long Hedger and Multiple Delivery Specifications on Futures Contracts," *Journal of Futures Markets*, 11, 557-565.

Lien, D. (1992): "Applications of Mean-Variance Analysis to Broad-Based Futures Contracts," *Journal of Futures Markets*, 12, 19-32.

Lien, D. and Balakrishnan, N. (2003): "Conditional Correlation Analysis of Order Statistics from Bivariate Normal Distribution with an Application to Evaluating Inventory Effects in Futures Markets," *Statistics and Probability Letters*, 63, 249-257.

Lien, D. and Luo, X. (1993): "A Theoretical Comparison of Composite-Index Futures Contracts," *Journal of Futures Markets*, 13, 821-836.

Lien, D. and Rearden, D. (1996): "A Property of Coefficients of Variation for Ordered Bivariate Log-Normal Variables," *Communications in Statistics: Theory and Methods*, 25, 1903-1916.

Lien, D. and Rearden, D. (1998): "Cross Moments of Extreme Observations from a Multivariate Lognormal Distribution," *Communications in Statistics: Theory and Methods*, 27, 601-607.

Lien, D. and Tse, Y. K. (1999): "The Effects of Cash Settlement on the Cash-Futures Prices and Their Relationships: The Case of Feeder Cattle and Live Hog," Working Paper, University of Kansas.

Lien, D. and Tse, Y. K. (2002): "Physical Delivery versus Cash Settlement: An Empirical Study on the Feeder Cattle Contract," *Journal of Empirical Finance*, 9, 361-371.

Lien, D. and Yang, L. (2003a): "Option Expiration Effects and the Role of Individual Share Futures Contracts," *Journal of Futures Markets*, 23, 1107-1118.

Lien, D. and Yang, L. (2003b): "Contract Settlement Specification and Price Discovery: Empirical Evidence in Australia Individual Share Futures Market," *International Review of Economics and Finance*, forthcoming.

Lien, D. and Yang, L. (2003c): "Alternative Settlement Methods and Australian individual Share Futures Contracts," Working Paper, University of Texas, San Antonio.

Lien, D. and Yang, L. (2003d): **"**Individual Stock Futures Markets and Expiration Day Effects: A Transaction Data Analysis," Working Paper, University of Texas, San Antonio.

Lin, B.-H. and Chou, J.-H. (1998): "Pricing and Hedging of Cash-Settled Bond Futures," *Journal of Financial Studies*, 5, 1-32.

Mollgaard, H. P. (1997): "A Squeezer Round the Corner? Self-Regulation and Forward Markets," *Economic Journal*, 107, 104-112.

Paul, A. (1985): "The Role of Cash Settlement in Futures Contract Specification," in: A. Peck (ed.) *Futures Markets: Regulatory Issues*. Washington, DC: American Enterprise Institute.

Paul, A. (1987): "Pricing Implications of Alternative Delivery Mechanisms for Futures Contracts," in: *Key Issues in Livestock Pricing*. Research Institute on Livestock Pricing, Blacksburg, Virginia.

Pirrong, C. (1993): "Manipulation of the Commodity Futures Market Delivery Process," *Journal of Business*, 66, 335-369.

Pirrong, C. (1995): "Mixed Manipulation Strategies in Commodity Futures Markets," *Journal of Futures Markets*, 15, 13-38.

Pirrong, C. (1997a): *The Economics, Law, and Public Policy of Market Manipulation*. Boston: Kluwer Academic Publishers.

Pirrong, S. C. (1998): "The Efficient Deterrence of Mnaipulation in Futures Markets," Mimeo. Washington University – St. Louis.

Rich, D. and Leuthold, R. (1993): "Feeder Cattle Cash Settlement: Hedging Risk Reduction or Illusion?" *Journal of Futures Markets*, 13, 497–514.

Rogers, L. C. G. and Satchell, S. E. (1991): "Estimating Variance from High, Low, and Closing Prices," *Annals of Applied Probability*, 1, 504-512.

Rowsell, J. and Purcell, W. (1990): "Impact of Cash Settlement on the Effectiveness of Price Discovery Processes in Feeder Cattle," Mimeo. Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Schmitz, J. (1997): "Basis Convergence in Cattle Contracts Before and After Changes to Delivery Specifications," Mimeo. University of Wyoming, Laramie, Wyoming.

Schroeder, T. and Mintert, J. (1988): "Hedging Feeder Steers and Heifers in the Cash -Settled Feeder Cattle Futures Market," *Western Journal of Agricultural Economics*, 13, 316–326.

Shah, A. (1998): "Improved Methods for Obtaining Information from Distributed Dealer Markets," Mimeo. Indira Gandhi Institute for Development Research, Bombay, India.

Sutcliffe, R. (1997): *Stock Index Futures*. Second edition, International Thompson, Boston, Massachusetts.